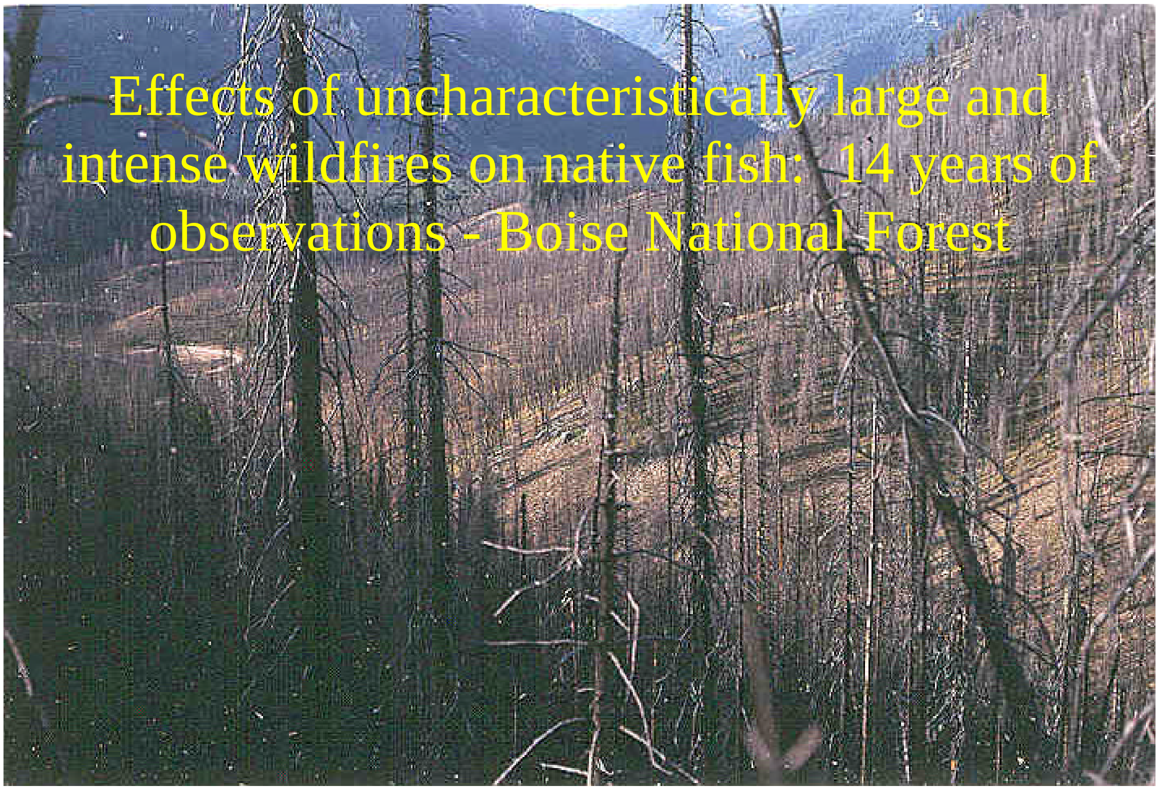
Effects of uncharacteristically large and intense wildfires on native fish: 14 years of observations - Boise National Forest



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October, 2000

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Effects of uncharacteristically large and intense wildfires on native fish: 14 years of observations on the Boise National Forest

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EXECUTIVE SUMMARY

Over 525,000 acres burned on the Boise National Forest from 1986 to 1994. We monitored fish abundance and stream habitat quality within watersheds associated with six fires, all of which burned more severely, and across larger areas than had been observed prior to 1986. The largest fires occurred mostly in dry forests types of ponderosa pine and Douglas fir. About 50 percent of the ponderosa pine-dominated forests on the Boise National Forest were burned during this time period. Although large and hot, these fires consumed vegetation in a mosaic of burn intensities, so that only 18 percent, on average, of a typical watershed area was burned at high intensity (hot enough to burn most of the overstory vegetation). Most watersheds experienced predominantly low intensity burning, while almost one third of the area within the average watershed did not burn at all. Where fire burned at high intensity adjacent to streams occupied by salmonids, direct mortalities were observed. But high intensity burning was only continuous over relatively short stream segments, so that many fish remained in adjacent stream reaches and others were likely able to seek refuge. Post-fire floods and debris flows associated with these mixed-intensity fires caused local, non-uniform degradation of stream habitats for native fishes. Because fire intensity varied greatly across the landscape, localized debris flows favored smaller order stream systems. Often unburned landscapes, and those that burned at low intensity, left islands or "refuges" containing fish and fish habitats not directly affected by the fire or adversely affected by post-fire floods and debris flows.

Of the 32 watersheds (6^{th} code HUCs) assessed, only one, Upper Rattlesnake Creek, burned mostly at high levels of severity (62%). Streams which experienced high levels of post-fire debris flooding were associated with small (7^{th} code or higher) watersheds that mostly burned at high severity (range = 60% to 88% of watershed area burned at high severity). Streams having little or no post-fire debris flooding were associated with large watersheds (6^{th} code or larger), or small watersheds having less than 37% of the area burned at high severity (range = 14% to 37% of watershed burned at high severity).

Stream habitat alterations resulting from the fires were never detected in most of the watersheds assessed. Habitat alterations were detected in watersheds with high levels of post-fire debris flooding. Characteristics of such watersheds are as follows:

Size: Average = 4000 acres, Range = 600 to 10,500 acres.
Percent of area burned at high severity: Average = 73%, Range = 60% to 88%.
Stream length: Average = 5.5 miles, Range = 2.5 to 11.2 miles.
Starting Elevation: Average = 4,900 feet, Range = 4,460 – 5,800 feet
Dominant Forest Cover = Douglas Fir/Ponderosa Pine, or Lodgepole pine/Subalpine fir
Dominant Landtype Association = Fluvial granitics

Less than 5 percent of the burn area, or about 25,000 acres, experienced severe post-fire debris flooding and stream habitat alterations. Habitat conditions and trout densities declined dramatically immediately following the debris flows. However, in the most severely impacted streams, habitat conditions and trout populations rebounded significantly, and often within only 5 years of the flood event. In some cases, large numbers of young-of-the-year and juvenile fish were observed in samples taken several years after the flood events, indicating strong productivity following the changes resulting from wildfire. The post-fire floods rejuvenated habitats by transporting fine sediments, and by bringing in large amounts of large rock, woody debris, and nutrients resulting in higher fish densities than before the fire. Redband trout are particularly productive in habitats with high pool frequency and low substrate fine sediments.

Effects of fires on bull trout and their spawning and early rearing habitats have been mostly neutral. These habitats, limited to colder streams above 5,000 feet elevation, are mostly above the elevational range typically associated with severe post-fire debris floods. Exceptions are the bull trout spawning habitats in Sheep and Rattlesnake Creeks, which experienced landslides and floods resulting in declines of large woody debris and bank stability, increased substrate fine sediment, and reduced pool frequency. High intensity burning produced localized fish mortalities and depauparate reaches interspersed with segments containing higher fish densities. Bull trout may have sought refuge into lightly burned and unburned tributary streams as a result of the intense heat and/or habitat alterations during and immediately after the fire. In Rattlesnake Creek, by the year 2000, large woody debris abundance had increased dramatically, as a result of fire-killed trees falling into the stream. Width-to-depth ratio of pools was greatly improved, as compared with 1994 pre-flood observations. These positive changes seemed to offset the negative effects of the debris flows, as evidenced by fish responses measured in the year 2000. Fish densities were up considerably, with bull trout abundance re-bounding to pre-disturbance levels, and redband abundance higher than any previous years' observations. Large bull trout were observed in Rattlesnake Creek, suggesting that re-population was enhanced by mobility and fecundity of the migratory component.

Most bull trout spawning and early rearing habitats were not adversely affected by post-fire temperature effects. Although overstory shade was reduced, most bull trout spawning streams are generally small enough to be shaded by understory riparian shrubs, which were vigorously regenerated after the fires. One exception was Ballentyne Creek, a stream wider than 5 meters. Thermograph data for the intensely burned Ballentyne Creek shows marked diurnal differences between measurements made in the stream with those in the unburned comparison stream, Upper Crooked River. Daily high temperatures are 4 to 5 degrees Celsius higher and daily lows are lower by a couple degrees in the burned stream in summertime. Wintertime differences are about 1 degree higher in the burned stream. Water temperature is often cited as a major determinant of bull trout distribution and productivity. Overall bull trout densities increased dramatically in the unburned watershed in the year 2000, while densities decreased in the burned watershed, suggesting that temperature increases may be depressing bull trout abundance on Ballentyne Creek.

These findings suggest that although fish populations can be depressed, and perhaps locally decimated by fires and post-fire debris floods, the fires and floods do not produce a complete elimination of the population, and more importantly loss of the migratory component. Adults emigrating from winter rearing areas into upstream spawning areas re-establish new groups of offspring after habitats have recovered. Larger migratory bull trout have been observed in the natal areas in September, the spawning period. There is evidence that recruitment of large woody debris from falling dead trees, and recruitment of large rocks and fine sediment removal by increased post-fire floods, actually enhanced the local environment, in particular the structure of the habitat. Increased large woody debris and deepened pools, along with a strong vegetative response by riparian communities, and likely nutrient flushes resulting from the post-fire ash flows may account for the higher densities of both bull trout and redband trout.


NF Boise River, 1995


NF Boise River, 2000 (same location)

Post-fire debris floods in tributaries of the NF Boise River deposited large volumes of fine sand in the river (LEFT photo above). By the year 2000, most of this sand had been moved out of the stream and into river bars (RIGHT photo above).

Large wildfires can have a dramatic effect on fish and fish habitat, but such effects are limited, both spatially and temporally. On a small scale, we have observed complete extirpation of a local population of redband trout after debris flooding. For at least one year this population was disconnected from the NF Boise River by a flood-generated barrier downstream. Re-colonization was delayed until the stream system naturally removed the barrier after spring flooding. A more permanent barrier would have prevented recovery of the population, and posed a serious risk to long-term viability. Fortunately, most severe disruptions and local extirpations are reversible, and sometimes recovery produces greater habitat diversity and productivity. Permanent downstream barriers to migration and potential exposure to increased solar radiation represent the greatest risks to bull trout after high intensity burning. In the future it will be important to assess burn intensity relative to these factors in spawning and early rearing habitats.

Effects of wildfires on fish: Boise National Forest

Introduction

Large fires burning in forest types of the Boise National Forest burned more severely across more area than was observed historically. During the past 14 years, about 50 percent of the ponderosa pine-dominated forests have been burned, at varying levels of severity. Many acres were burned at uncharacteristically high severity. Table 1 summarizes the large wildfires discussed in this paper:

The locations of these fires are shown on the map in Figure 1.

Fire severity data were available for the three most recent wildfires. These are also the largest of the six wildfires evaluated. Fire severity is defined as follows:

> **Low**: A cool fire that has minimal impact on the site, burning in surface fuels and consuming only the litter, herbaceous fuels, and foliage and small twigs on woody undergrowth.
>
> **Moderate**: A fire that consumes litter, upper duff, understory plants, and foliage on understory trees. If fuel ladders exist, individual trees or groups of overstory trees may torch out.
>
> **High:** A severe fire burns through the overstory, consumes large woody surface fuels, and may remove the entire duff layer over much of the area. These tend to render portions of the soil "hydrophobic", or resistant to infiltration.

Table 1. . Large fires on the Boise National Forest

Fire	Year	Size Acres	% burned at high severity	% burned at mod severity	% burned at low severity
Thunderbolt	1994	18,014	34%	50%	16%
Rabbit Creek	1994	177,077	26%	26%	48%
Foothills	1992	225,856	13%	14%	72%
Lowman	1989	44,374	not available	not available	not available
Deadwood Summit	1987	53,451	not available	not available	not available
County Line	1992	8,000	not available	not available	not available

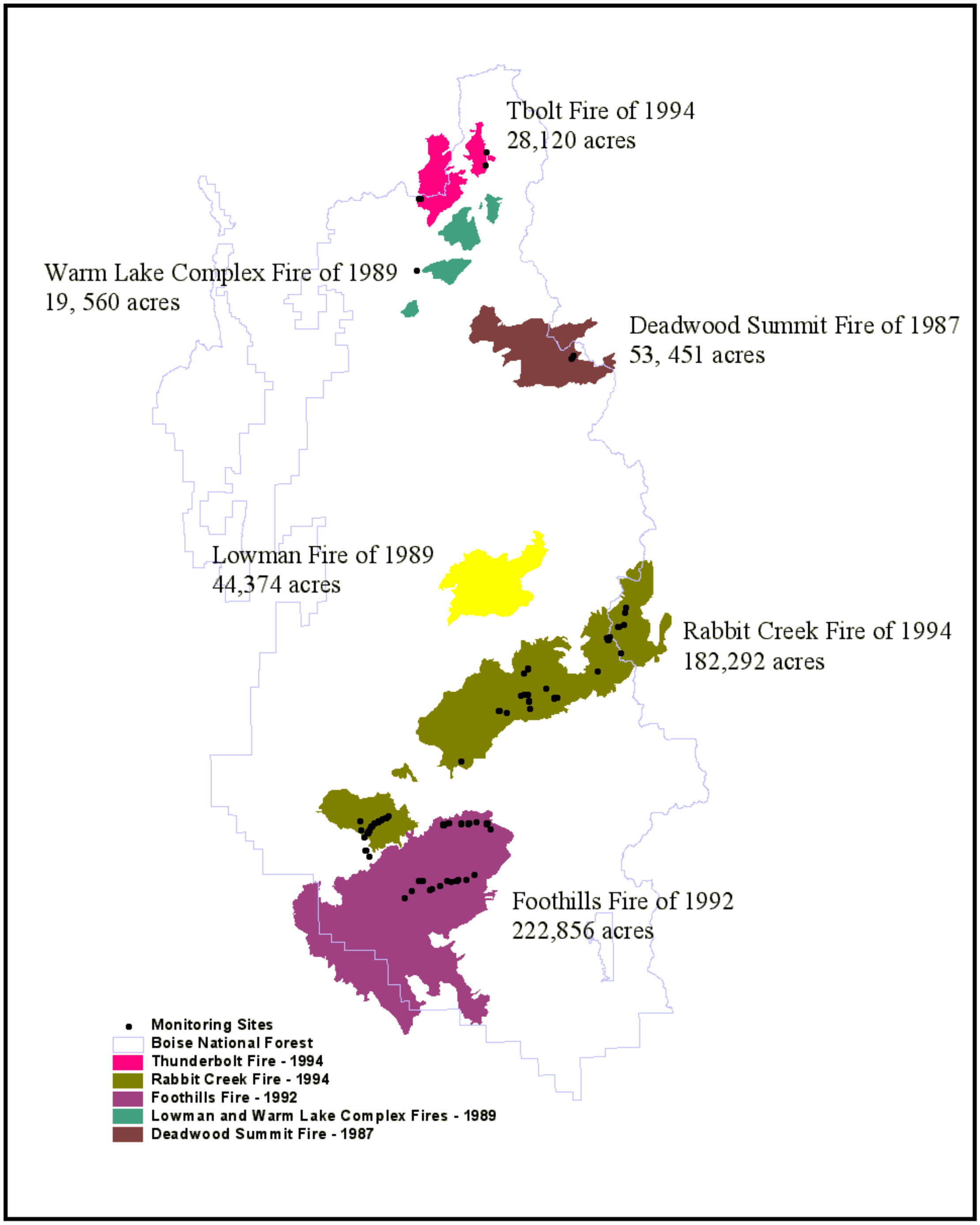

Figure 1. Large Fires on the Boise National Forest, 1987 to 1994

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None of the large fires burned at high severity over the majority of the fire area. Thunderbolt burned mostly at Moderate severity, while Rabbit Creek and Foothills burned mostly at low severity. At smaller scales, only one 6th code watershed burned mostly at high severity, while most watersheds burned mostly at low or moderate severity. Table 2 summarizes watershed burn severities for 32, 6th code watersheds associated with three large fires on the Boise National Forest. Figure 2 depicts the severity of fires with respect to the 6th code watersheds used in this analysis.

Of the 32 watersheds assessed, only one, Rattlesnake Creek, burned mostly at high levels of severity. On the average, only 18 percent of the area within the 6th code watersheds burned at high severity. Most watersheds experienced primarily low severity burning, and almost one third of the area within the average watershed did not burn at all. These data show that large fires on the Boise National Forest burned mostly in a mosaic of high, moderate, and low severity, with portions of the watersheds left unburned. Post-fire floods and debris flow events within the lands burned by these mixed-intensity fires caused local, non-uniform degradation of stream habitats for native fishes. Because severity of the fires varied greatly across the affected area, localized debris flows favored smaller order stream systems. Often unburned landscapes, or those that burned at low intensity, left islands or “refuges” containing fish not directly affected by floods or other post-fire events.

Results of post-fire monitoring

We examined trends in fish abundance and fish habitat quality at stations downstream of high, moderate, and low severity burned landscapes, at varying hydrographic scales. Several streams were selected for assessment where pre- and post-fire monitoring data are available. Characteristics of these streams/watersheds are summarized in Table 3, and the following:

> **Severe post-fire impact**: Streams which experienced high levels of post-fire debris flooding were associated with watersheds that mostly burned at high severity (range = 60% to 88% of watershed area burned at high severity), and fluvial granitics as the dominant landform. Fluvial granitics are steep, deeply dissected mountains with sharp ridges and V-shaped valleys. These watersheds were mostly associated with Douglas fir and ponderosa pine, although subalpine fir and lodgepole pine were also important forest cover in some watersheds.
>
> **Low post-fire impact**: Streams having little or no post-fire debris flooding were associated with watersheds having less than 37% of the area burned at high severity (range = 14% to 37% of watershed burned at high severity). Glacial granitics were the dominant landform. Glacial granitics are U-shaped glacial valleys with gently sloping alluvial bottoms adjacent to and below rocky ridges and cirque basins. These watersheds were associated mostly with subalpine fir and lodgepole pine.

Monitoring data from 5 different fires were examined to assess effects on fish and fish habitat. The following sections summarize each of the streams/watersheds and post-fire/flooding effects on stream habitat and fish abundance.

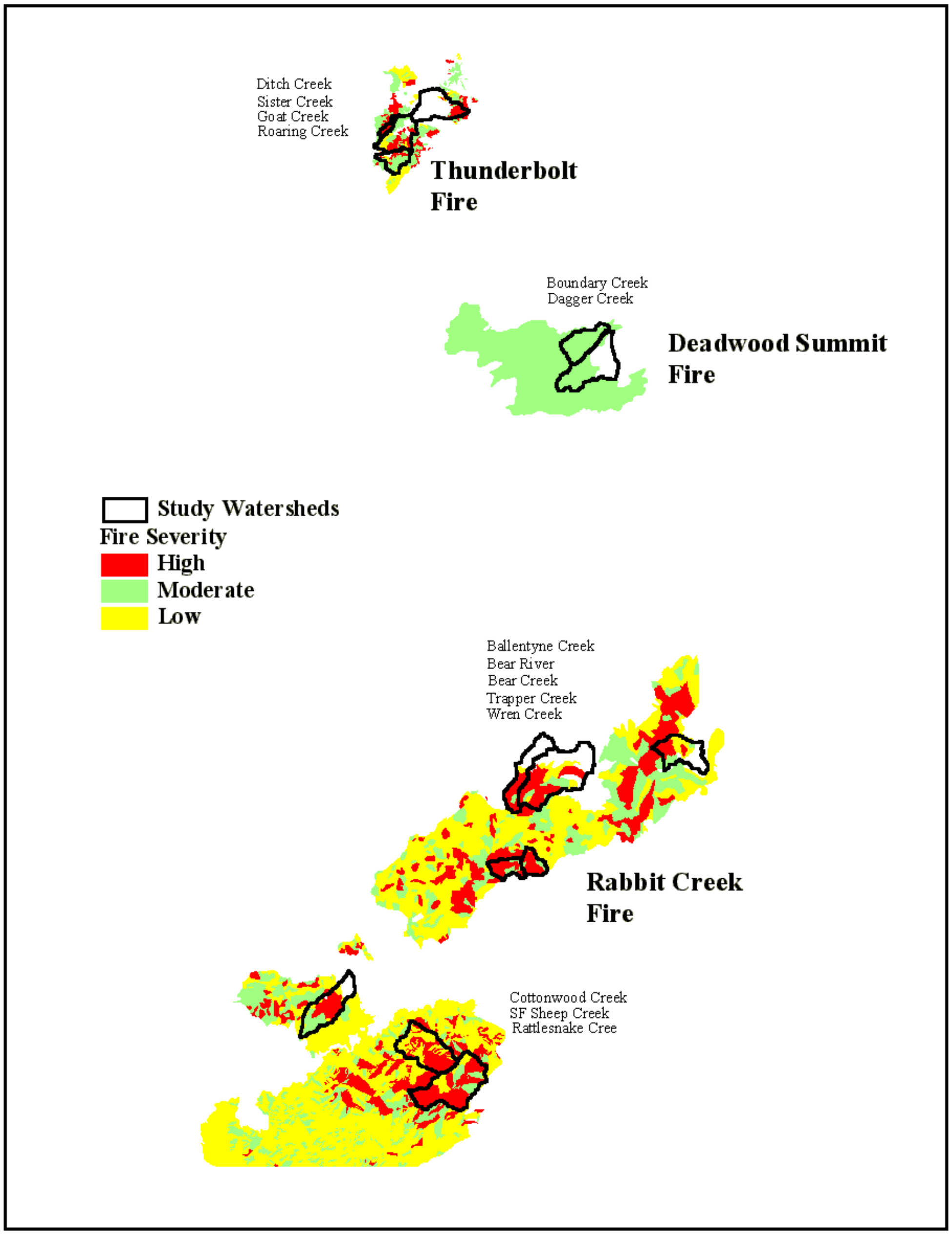

Figure 2. Fire severity and watersheds monitored for effects of large, intense wildfires on fish abundance and habitat, Boise National Forest

Table 2. Burn severities by watershed, Boise National Forest (H = High, M = Moderate, and L= Low severity).

HUC6NAME	Watershed acres	H	M	L
Badger-Slide	16,960	6%	10%	58%
Big Fiddler-Soap	17,918	1%	17%	81%
Big Owl-Wren	15,416	30%	23%	46%
Black Canyon-Trail	25,741	2%	9%	37%
Cliff-Goat	12,885	41%	0%	0%
Cottonwood Creek	14,686	21%	17%	17%
Deer-Grouse	30,455	1%	9%	27%
Fourmile Creek	9,837	10%	13%	13%
Halfway	16,265	11%	13%	1%
Hungarian-Beaver	14,459	18%	7%	33%
Johnson Creek	16,970	18%	36%	26%
Lambing-Trail	8,482	14%	7%	66%
Long Gulch	6,283	19%	35%	46%
Lower Bear River	8,969	27%	5%	38%
Lower Crooked River	14,558	19%	9%	50%
Lower Rattlesnake	15,401	38%	9%	52%
Lower Sheep	11,493	40%	5%	55%
Lower Smith Creek	14,957	4%	10%	56%
Lower Thorn	8,603	13%	31%	18%
Minneha-Wildcat	8,386	16%	42%	17%
Rabbit Creek	20,666	8%	16%	49%
Silver-Cow	17,183	27%	41%	18%
Taylor-Lodgepole	18,284	6%	17%	47%
Trapper-Trail	13,137	26%	31%	42%
Two-Bit-Roaring	11,915	5%	14%	3%
Upper Bear River	13,694	38%	9%	14%
Upper N Fk Boise River	18,719	41%	10%	24%
Upper Rattlesnake Creek	12,951	62%	21%	17%
Upper Sheep Creek	16,048	18%	10%	52%
Upper Thorn Creek	8,746	3%	3%	10%
Upper Willow Creek	15,797	0%	10%	69%
Wood Creek	14,589	0%	25%	74%
Average		18%	16%	36%

Table 3. Characteristics of severely burned watersheds on the Boise National Forest.

Watershed	Size (acres)	% High Severity	% Moderate Severity	% Low Severity	% Not burned	Stream Length (meters)	Lower Elevation (meters)	Upper Elevation (meters)	Basin Gradient	Dominant Landtype Association	Dominant Forest Cover	Post-Fire debris flooding
Sister Creek	598	88%	11%	1%	0%	4000	1500	2420	0.23	Fluvial granitics	SF/LP	High
Boundary Creek	4296	60%	35%	5%	0%	8509	1767	2194	0.05	Fluvial granitics	SF/LP	High
Wren Creek	2500	75%	24%	0%	1%	7376	1360	2060	0.09	Fluvial granitics	DF/PP	High
Trapper Creek	2201	76%	20%	3%	1%	5627	1490	1980	0.09	Fluvial granitics	DF/PP	High
Rattlesnake Creek	10454	64%	15%	20%	1%	18584	1380	2170	0.04	Cryic mountains	DF/PP/SF	High
Roaring Creek	1877	29%	59%	12%	0%	4939	1490	2300	0.16	Glacial granitics	SF/LP	Low
Goat Creek	4319	30%	35%	17%	18%	7357	1440	2400	0.13	Glacial granitics	SF/LP	Low
Ditch Creek	5092	14%	4%	1%	81%	9117	1620	2510	0.10	Glacial granitics	SF/LP	Low
Ballantyne Creek	5484	29%	14%	23%	34%	9724	1870	2540	0.07	Glacial granitics	SF/LP	Low
Cottonwood Creek	6638	37%	28%	15%	21%	9989	1160	2130	0.10	Cryic mountains	DF/PP/SF	Low
Bear River	13416	37%	9%	14%	40%	14474	1520	2390	0.06	Glacial granitics	DF/PP/LP	Mod
Bear Creek	5215	36%	4%	9%	51%	13049	1510	2390	0.07	Cryic mountains	DF/PP/LP	Mod
SF Sheep Creek	7891	50%	1%	49%	1%	6666	1130	1640	0.08	Fluvial granitics	DF/PP	Mod

RABBIT CREEK FIRE OF 1994

INTRODUCTION

The Bull Trout Problem Assessment for the Boise River Basin, prepared by the Southwest Basin Native Fishes Watershed Advisory Group (SBNFWAG), emphasizes the need to assess, long-term, responses of bull trout and associated habitats to fires. Factors of greatest interest are: Fish abundance, sediment in spawning areas, temperature in early rearing areas, large pool abundance in rearing and overwintering areas, bank stability in meadow streams, and large woody debris abundance in forested streams. Fish and habitat monitoring has been conducted since the Rabbit Creek fire of 1994.

Approximately 184,500 acres of National Forest System lands, mostly within the NF Boise Basin, Boise National Forest, were burned in late summer 1994. The Rabbit Creek Fire burned about one-third of the acreage at high intensity. In 1994 a monitoring program was initiated to assess effects of the fire on fish and fish habitats. Many of the stations selected for monitoring were on streams supporting bull trout and redband trout spawning and early rearing, in both burned and unburned watersheds. Unburned watersheds were selected to serve as a control. Habitat monitoring on stream reaches containing 30 consecutive main channel pools was conducted using a refinement of the R1/R4 habitat survey protocol. Electrofishing transects, each at least 100 meters in length, were established at the downstream end of each habitat monitoring reach.

For this report, a subset of the monitoring stations, associated with streams/watersheds burned mostly at high intensity, were selected for analysis (Figure 3). Upper North Fork Boise River, and Ballentyne Creek occur at higher elevations where bull trout spawn and rear. Trapper and Wren Creeks occur at lower elevations where redband trout spawn and rear. Bull trout have not been observed in Trapper and Wren Creeks.

Key Assumptions

1. Habitats at selected stations are representative of bull trout habitats across the local population watershed.

2. Fish densities at selected stations are representative of bull trout densities for entire reaches (local populations) of associated streams.

Methodology

Habitat: Standard protocols as outlined in Overton and others (1995) were used to measure the habitat features.

1.Habitat type, length, and width: The habitat types listed on pages 24 to 26 of Overton and others (1995) are recorded, as well as thalweg length and average wetted width of each unit.

2.Slow water (pool) max depth, crest depth, step pool #, # pools >1M (deep pools), and max sediment depth: Use the protocols on pages 27 and 28 of Overton and others (1995)

3. Surface fines (percent): Percent surface fines were estimated at each scour pool tail. Percent surface fines was measured using a 100-intersection grid.   A plexiglass viewer was used to count the occurrences (grid intersections) where substrate is smaller than 6mm

4. Fish abundance: Fish abundance was estimated using 2-pass electrofishing techniques.

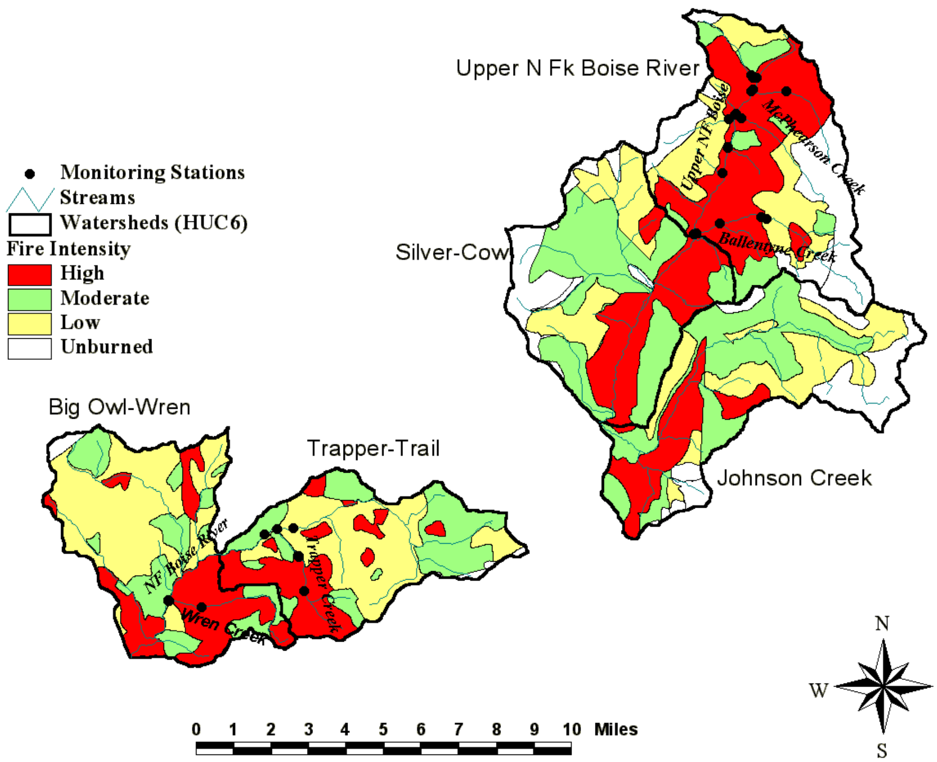

Figure 3. Watersheds selected for fish and fish habitat assessment within the Rabbit Creek Fire showing locations of the monitoring stations with respect to burn intensity.

Monitoring Results

Wren/Trapper Creeks

Severe flooding drastically altered stream habitats in Trapper and Wren Creeks in 1995, one year after the fire (Figure 4). Additional debris flows occurred in 1996. Table 4 summarizes the findings from this assessment.

Table 4. Fish and fish habitat trends following the 1994 Rabbit Creek Fire and 1995/96 debris floods, NF Boise Basin.

Trapper Creek

Period	**Spawning fines (%)**	**Pools (%)**	**Pool frequency (#/mi)**	**LWD (pieces/mi)**	**Redband trout density (#/mi)**
Pre-fire	40	16	139	416	860
1995-1997	24	1	9	50	32
2000	23	15	83	80	982

Wren Creek

Period	**Spawning fines (%)**	**Pools (%)**	**Pool frequency (#/mi)**	**LWD (pieces/mi)**	**Redband trout density (#/mi)**
Pre-fire	33	56	386	193	515
1995-1997	40	2	29	40	0
2000	45	47	267	150	697

Habitat conditions and trout densities declined dramatically immediately following the debris floods in 1995/96. However, just 4 years later in 2000, habitat conditions and redband trout populations rebounded significantly. Large numbers of young-of-the-year and juvenile fish observed in the year 2000 samples indicated strong productivity following the changes resulting from wildfire. Redband trout are particularly productive in habitats with high pool frequency and low substrate fine sediments. The post-fire floods rejuvenated habitats by bringing in large amounts of large rock, woody debris, and nutrients that resulted in higher fish densities than before the fire. These observations suggest that debris floods following wildfires in the Boise Basin may be positive for redband trout.

Figure 4. Mouth of Trapper Creek in 1996 (left), and in 2000 (right).

Figure 5.   Trapper Creek in year 2000 with pools formed by large woody debris and large rocks.

Upper NF Boise River

Three stream reaches were monitored between 1994 and 1999, Upper NF Boise River, Ballentyne Creek, and McCloud Creek.   During those years, the downstream starting location for each stream reach was consistent, but the length of stream surveyed varied from year-to-year. Generally, the length surveyed increased through time. Relative abundances of redband and bull trout, along with habitat conditions are diplayed in Tables 5, 6, and 7.   Redband trout decreased slightly from 1994 to 1999 at Upper NF Boise, but increased in Ballentyne Creek. No redband trout have been observed in McCloud Creek. Bull trout abundance declined slightly between 1995 and 1999 in Upper NF Boise River, but stayed about the same in Ballentyne and McCloud Creeks.   There are no clear trends in any of the fish density data from 1994 to 1999.

Width-to-depth and width-to-maximum depth ratios are unchanged, or have decreased through time. These findings reflect the fact that post-fire debris floods have not occurred,   therefore there has been little or no stream channel scour in the upper NF Boise Basin.

Substrate fines increased after the 1994 fire at two sites. Average increases were: 16% (Upper NF Boise), and 14% (Ballentyne Creek). McCloud Creek showed a significant decrease of 25%.   The change in McCloud Creek may reflect some stream scour.

Pool composition and frequency has generally increased through time. Increases on McCloud Creek may reflect the addition of large woody debris since 1995. It is not known why pools have increased in the Upper NF Boise and Ballentyne Creeks.

Figure 6. . Electroshocking Ballentyne Creek on the Upper NF Boise River, 1995.

Table 5. Monitoring results for the Upper NF Boise River

Year	Length Surveyed	Redband trout (#/mile)	Bull trout (#/mile)	Width-to-depth ratio	Width-to-max depth ratio	Substrate fines (%)	Percent pool	Pool Frequency (#/mile)	Large woody debris (#/mile)
1994	182	110	97	24	10	19%	47%	134	221
1995	184	90	125	22	7	33%	53%	151	84
1997	100	32	16	na	na	na	na	na	na
1999	320	79	61	25	10	35%	49%	195	92

Table 6. Monitoring results for Ballentyne Creek

Year	Length Surveyed	Redband trout (#/mile)	Bull trout (#/mile)	Width-to-depth ratio	Width-to-max depth ratio	Substrate fines (%)	Percent pool	Pool Frequency (#/mile)	Large woody debris (#/mile)
1995	160	0	497	20	9	16%	38%	88	156
1996	398	0	241	16	6	na	34%	113	117
1997	398	16	563	13	7	27%	30%	85	178
1999	300	130	480	19	10	30%	61%	316	81

Table 7. Monitoring results for McCloud Creek

Year	Length Surveyed	Redband trout (#/mile)	Bull trout (#/mile)	Width-to-depth ratio	Width-to-max depth ratio	Substrate fines (%)	Percent pool	Pool Frequency (#/mile)	Large woody debris (#/mile)
1995	83	0	330	12	4	40%	56%	233	39
1999	200	0	260	8	3	15%	61%	365	126

Temperature

Thermographs were installed on Ballentyne Creek, burned mostly at high intensity, and the unburned Upper Crooked River, in the summer of 1999. Approximately 27,000 temperature measurements were made at 15 minute intervals from August 1999 through July of 2000.

Although riparian willow communities have regenerated since the fire, overstory vegetation was completely burned, and the small amount of shade that has been provided by the burned stems is gradually declining as dead trees fall over.   These two streams were selected for comparison because both are shaded by overstory vegetation, have about the same water surface exposure (average 5 meters in width), both are on a west-southwest aspect, and elevation is approximately 5500 feet at both instrument stations. Overstory cover differences are evident in the photographs of Figure 7, and temperature differences are displayed in Figure 8.

Thermograph data for Ballentyne Creek show marked diurnal differences from measurements made in Upper Crooked River. Daily high temperatures are 4 to 5 degrees Celsius higher and daily lows are lower in the burned stream in summertime. Wintertime differences are less, about 1 degree higher in the burned stream.

Water temperature is often cited as a major determinant of bull trout distribution, with cold water a specific requirement for rearing (Rieman and McIntyre 1993).   For this reason we examined bull trout densities by size class at the thermograph stations on Ballentyne Creek and Upper Crooked River. These data are presented in Table 8, and the graph of Figure 9.

Figure 7. Streams assessed for water temperature. LEFT: Exposed Ballentyne Creek 4 years after the Rabbit Creek Fire. CENTER: Unburned Upper Crooked River. RIGHT: Bear Creek in 2000 showing understory shade recovery.

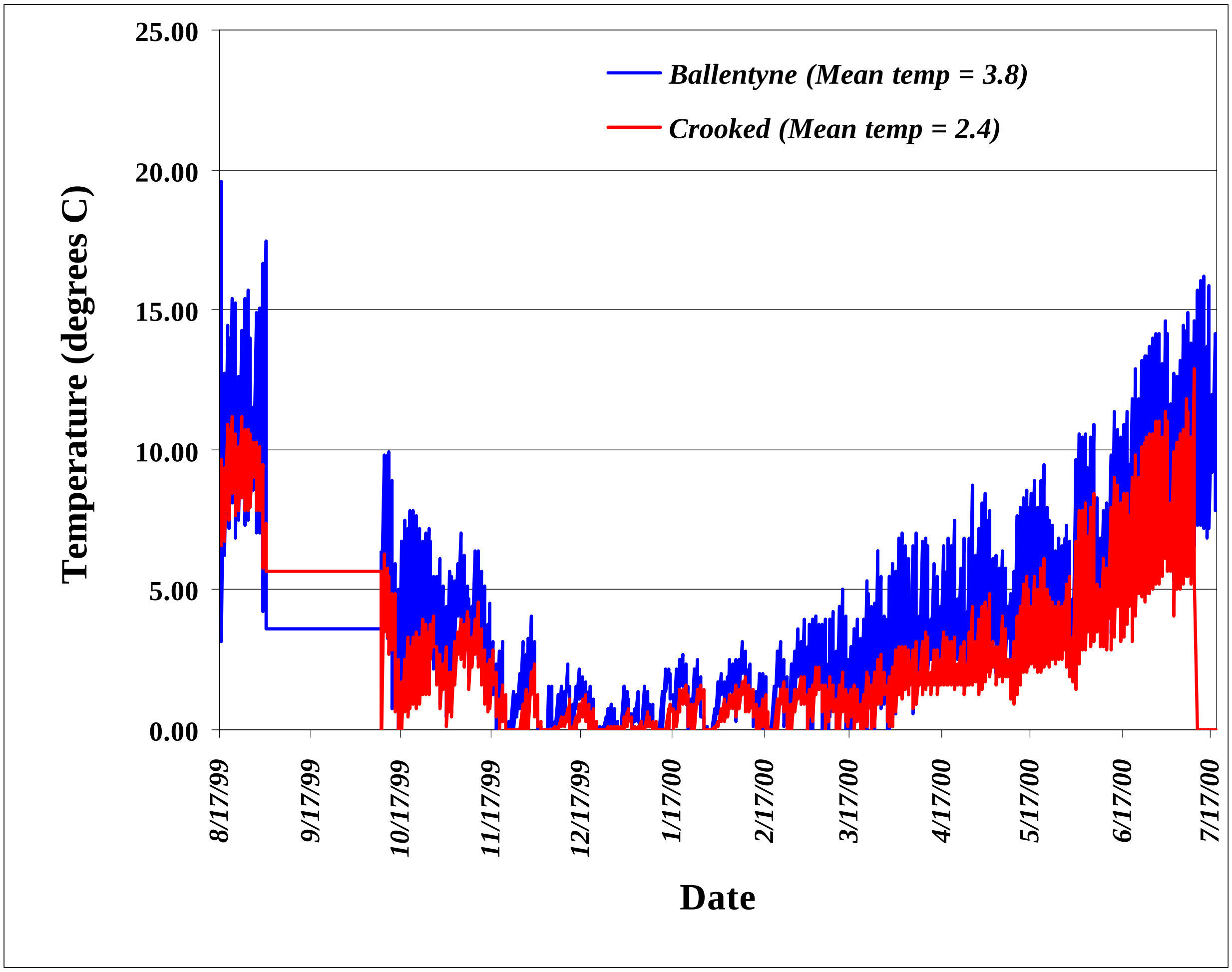

Figure 8. Temperatures (degrees C) in Ballenyne Creek (burned) and Upper Crooked River (unburned) taken at 15 minute intervals from 1999-2000

Table 8. Bull trout numbers by size class: Ballentyne Creek and Upper Crooked River.

Year	Size 0 - 100 mm		Size 100 - 200 mm		Size 200 - 300 mm		Bull Trout Density	
	Ballentyne	Upper Crooked	Ballentyne	Upper Crooked	Ballentyne	Upper Crooked	Ballentyne	Upper Crooked
1994		1		1		0		36
1995	13		0		0		349	
1996	5	0	9	1	1	0	241	16
1997	3		20		12		563	
1999	2	2	14	1	3	0	306	53
2000	11	10	4	9	1	1	274	322

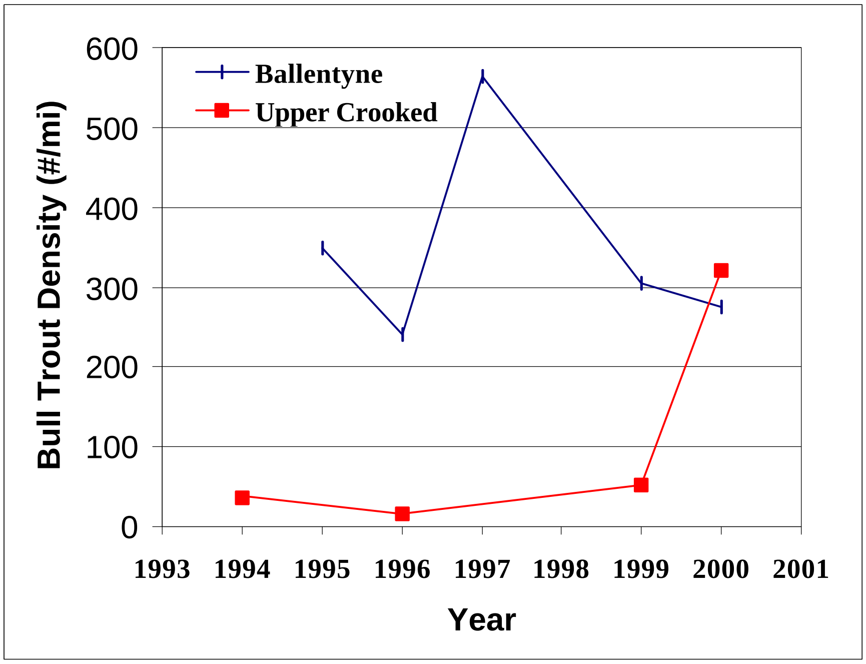

Figure 9. Trend in bull trout densities on Ballentyne Creek (burned) and Upper Crooked River (unburned) after the Rabbit Creek Fire of 1994.

Temperature monitoring results do not show a clear trend in productivity of any single size class, however there is some indication that size 0-100mm bull trout increased in abundance in 2000 as compared with previous years. Upper Crooked River did not show the same shift in size classes. Overall bull trout densities increased dramatically in the unburned watershed in the year 2000, while they decreased in the burned watershed. The trends in Figure 9 show that increases detected in the unburned stream, in 2000 were not observed in the burned area. Trends in bull trout density in Ballentyne Creek are not statistically significant, and it is difficult to assess an effect on the basis of one year's data. Additional monitoring will be needed to assess whether there is a long-term adverse affect from the loss of shade on Ballentyne Creek.

Similar down-trends in bull trout density were not observed on other headwater streams in the North Fork Boise Basin. Likewise, temperature departures from the unburned Crooked River were not observed on these other streams, such as Bear Creek shown in Figure 8. Most bull trout spawning and early rearing streams in the basin are small in width, and shaded largely by understory vegetation. Post-fire re-growth of understory vegetation has been vigorous.

DEADWOOD SUMMIT FIRE OF 1987

Three tributaries of the Middle Fork Salmon River were monitored for substrate fines and substrate particle size distribution before and after erosional events associated with the Deadwood Summit Fire of 1987 (Potynody 1990). Sulpher, Elk, and Boundary Creeks are associated with watersheds dominated by lodgepole pine forests, with streams flowing through forests and low-gradient meadows. These watersheds were burned at varying degrees of intensity. Sulpher Creek was least impacted by the fire (burned at light intensity over 95% of the area). Elk Creek experienced moderate impacts with 30% of the area burned at high intensity, but large portions of Elk Creek were unburned (Figure 10). Boundary Creek was heavily impacted by the fire. All of Boundary Creek watershed was burned, and 66% of the area burned at high intensity.

Substrate size distribution and percent fines data were collected using the Wolman Technique (Wolman 1954). Using this method, 100 substrate particles are collected and measured along cross-channel transects. The pebble count begins at bankfull stage on one bank and proceeds to the same stage on the other side of the stream. Samples are collected by pacing. At each pace, the observer reaches down to the tip of the boot and selects a particle with the index finger.

Monitoring Results

Table 9 displays results of substrate fines monitoring at the three stations. Sulphur and Elk Creeks showed no change in surface fine sediments from pre-fire condition. Boundary Creek showed a dramatic and significant increase in fine sediments the first year after fire. Substrate conditions returned to pre-fire characteristics the 2nd and 3rd years after the burn. The median particle size of substrates in Boundary Creek was gravel prior to the fire (d50 = 25mm). After the sedimentation event in 1988, median particle size shifted to sand (d50 = .7mm). In 1989, median particle size returned to pre-fire condition (d50 = 27mm), and remained at that size through 1990.

Observations in the Deadwood Summit Fire suggest that sedimentation events can occur

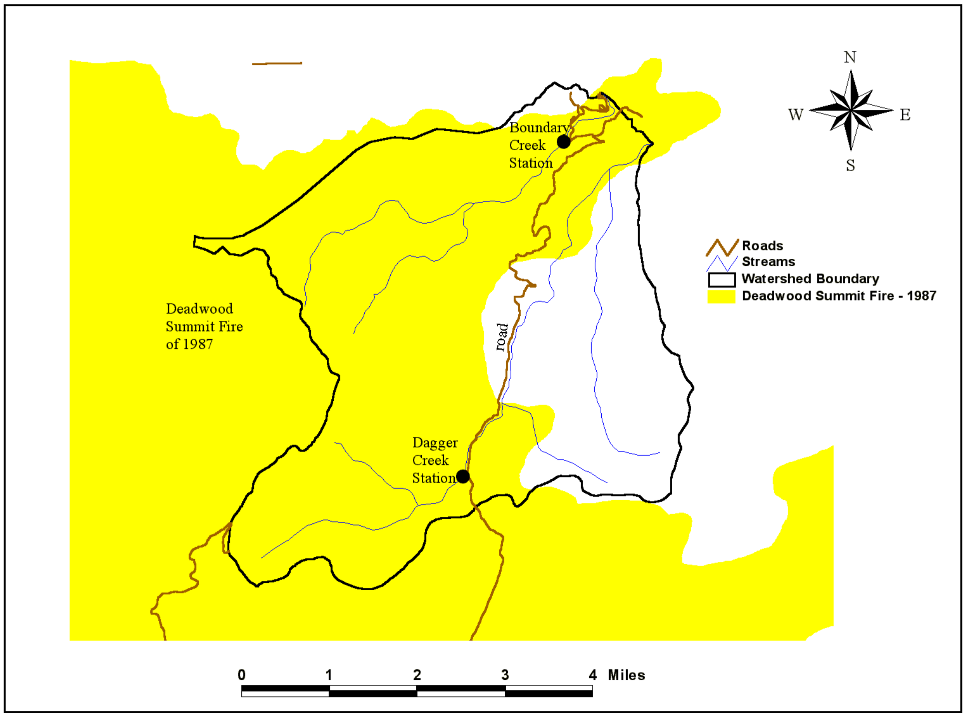

Figure 10. Deadwood Summit Fire of 1987, showing the locations of monitoring stations in Boundary Creek.

Table 9.   Trends in substrate fines (<4mm) at three monitoring sites in the Deadwood Summit Fire.

Monitoring Site	**Relative Fire Impact**	**Percent fine sediment**			
		Pre-Fire 1987	**1988**	**Post-Fire 1989**	**1990**
Boundary Creek	High	36%	63%	35%	33%
Elk Creek	Moderate	15%	10%	12%	na
Sulphur Creek	Low	20%	19%	8%	15%

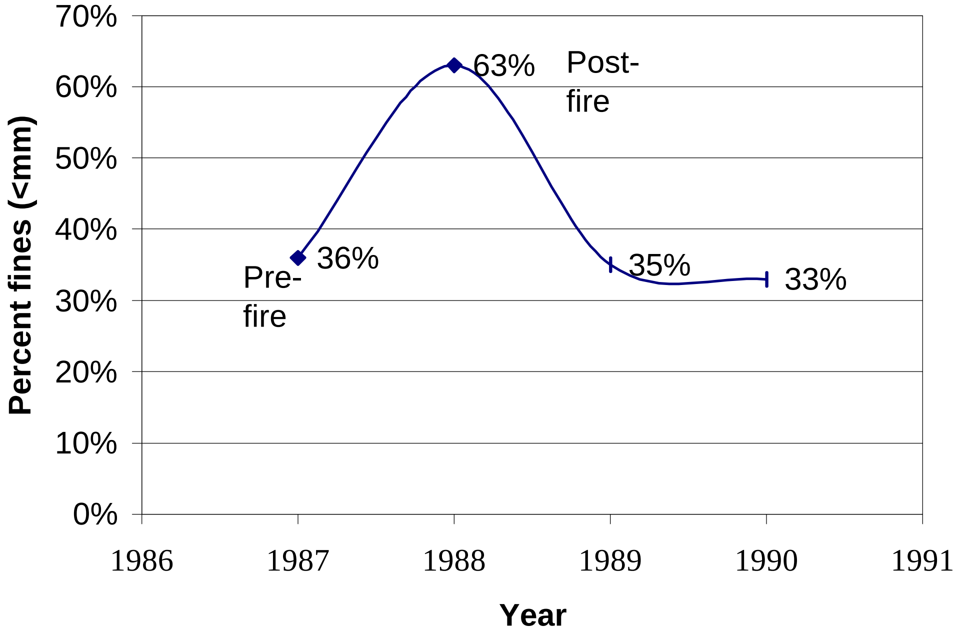

Figure 11. Trend in substrate fines at the Boundary Creek monitoring station, showing increase one year after the fire, followed by quick recovery.

Figure 12. Monitoring station on Boundary Creek, showing heavily sediment substrate in 1988, one year after the fire.

Figure 13. . Boundary Creek watershed, showing the extent and intensity of burning after the Deadwood Summit Fire of 1987.

Figure 14. The Dagger Creek monitoring station showing clean substrate after mostly light intensity burning.

COUNTY LINE FIRE OF 1992

Approximately 2500 acres of the 8000 acre County Line Fire burned within the Fir Creek Watershed. Within this watershed, the fire burned mostly at high intensity (Figure 15). The subalpine fir and lodgepole pine stands in this watershed are associated with a unique combination of topography, climate, and vegetation that is typified by large-scale, stand replacement fires.

That portion of Fir Creek burned by the County Line Fire is located mostly within the Red Mountain Roadless area. Other than the Fir Creek road, human disturbances are mostly absent in this drainage (see Figure 16). With a mean annual temperature of 36º Fahrenheit, the area is one of the coldest in the state. The average summer (June through August) temperature is 43 to 48º, while the winter average is 19 to 26º depending on elevation and location (Lowman Ranger District undated). Diurnal fluctuation in temperature is greatest in the summer, with an average range of about 43º. Summer daily highs average around 80º, while summer lows average about 37º. Growing conditions are harsh, making revegetation a slow process

High intensity stand replacement fires in the Fir Creek area were observed to denude the forest floor of effective ground cover, exposing bare soil to erosive forces for some period of time. Once a vegetative layer is re-established, surface erosion presumably would decline dramatically. Recovery of the ground cover has been slow. The most significant erosional event occurred 5 years after the fire, in 1997.

Figure 15. : The County Line Fire burns in Fir Creek Watershed, August, 1992. RIGHT: Aftermath of the fire resulted in subalpine fir and lodgepole pine stand replacement.

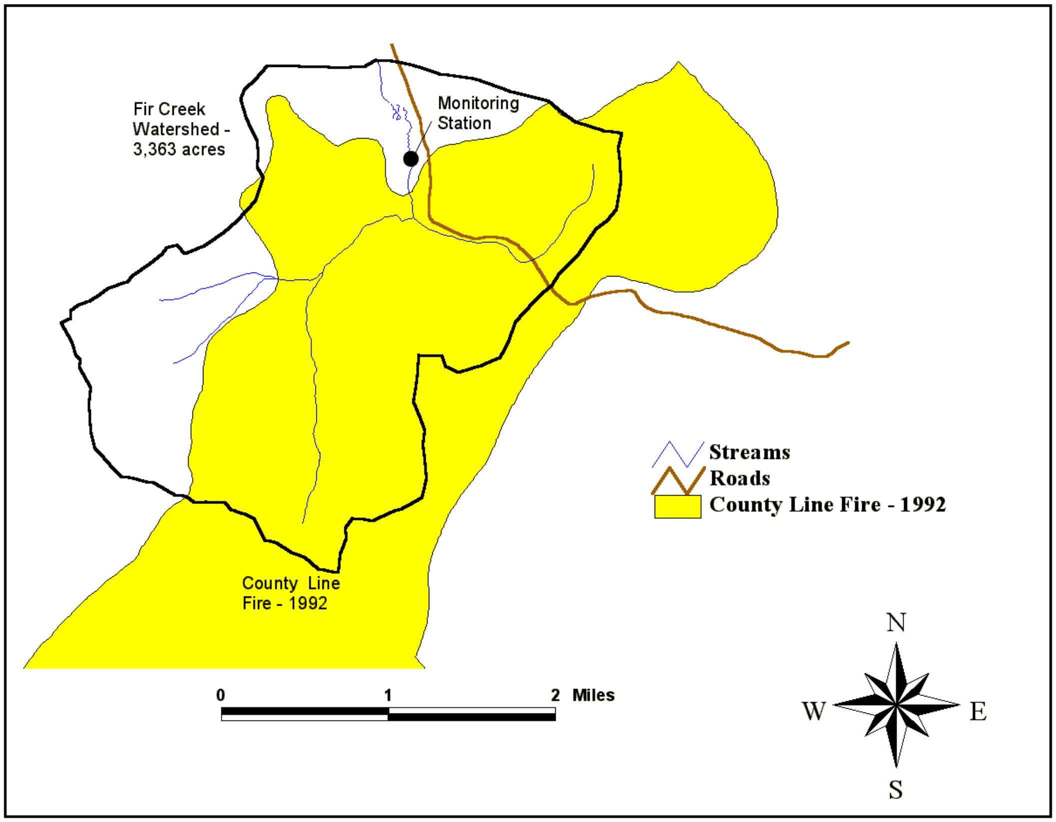

Figure 16. Map of the Fir Creek Watershed showing the location of the County Line Fire of 1992 and the monitoring station.

Monitoring Results

After the fire, a monitoring station was established on Fir Creek just downstream of the burned area in 1993 (Figure 3).   Substrate fine sediment was monitored at permanently staked cross sections on the stream. Percent fine sediment was estimated using two techniques, Wolman (Woman 1954), and the 100-intersection grid.   Using the Wolman technique, 100 substrate particles are collected and measured along a cross-channel transect. The pebble count begins at bankfull stage on one bank and proceeds to the same stage on the other side of the stream. Samples are collected by pacing. At each pace, the observer reaches down to the tip of the boot and selects a particle with the index finger.   The grid technique is conducted along the same transected used to collect pebbles in the Wolman technique. The grid is placed at 2 meter intervals along the transect (or less if stream width is narrow enough to prevent collecting at least 3 samples). The metal grid is placed directly on the substrate so that grid intersections can be associated with the substrate sizes over with they lie. A plexiglass viewer is used to count grid intersection located directly over fine sediments less than 6mm in size. Grid intersections are spaced at 24 mm so that fines can be easily identified.

Results of the monitoring are displayed in Table 10 and in Figure 17.

Figure 17. Fir Creek monitoring station, showing stream substrate in the year 2000. The island forming in the center of the channel is new since 1997.

Table 10. Fine sediment observations on Fir Creek using Grid and Wolman Techniques, 1993 to present.

Year	%Grid Fines	% Wolman Fines
1993	25%	
1995	30%	
1996	31%	44%
1997	65%	54%
1998	35%	25%
1999	33%	29%
2000	9%	10%

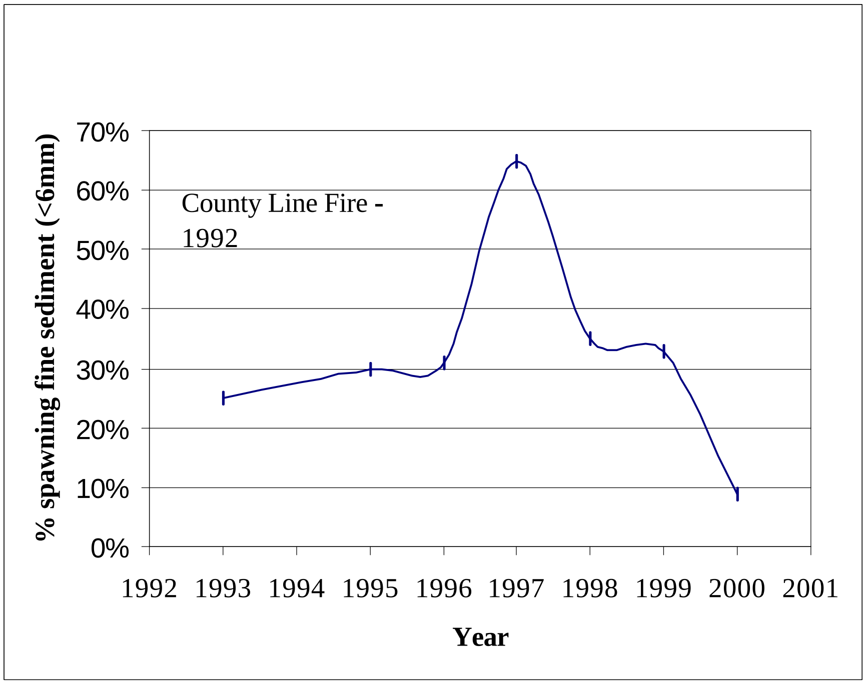

Figure 18. Trend in spawning fines on Fir Creek since the 1992 County Line Fire.

Conclusions

The spring runoff event of 1997 likely resulted in erosion and sedimentation of Fir Creek.   That year recorded the highest total precipitation since records started at nearby Banner Summit in 1981, at 60 inches.   Since most precipitation came in the form of snow, it is assumed that a substantial runoff event occurred in the spring of 1997. Substrate fines increased dramatically that year, apparently a result of the erosion event. Since 1997, substrate fines have declined to less than 10 percent. Although the fire apparently induced increased sedimentation, delayed until a significant runoff event occurred in the watershed, the effect was temporary. In the year 2000, substrate fines were well below the 7-year average.

FOOTHILLS FIRE OF 1992

The 250,000 acre Foothills Fire of 1992 is the largest wildfire to occur on the Boise National Forest in over 100 years. Two watersheds, Rattlesnake and Sheep Creeks, were burned intensively by the fire, and both support populations of bull trout and redband trout. The forests in these watersheds are dominated by warm, dry Ponderosa pine and Douglas fir habitat types. Such forests occur in discontinuous patches across the landscape, and they normally burn in a mosaic pattern of intensely burned, lightly burned, and unburned areas (see photo in Figure 19). Prior to settlement, fire was a frequent event in these forest types, occurring at intervals of approximately 11 years. Since 1900, fire suppression has eliminated burning in the Rattlesnake/Sheep Creek watersheds so that by 1992, fuel build-up was sufficient to create hotter than normal burn intensities. Consequently, these two drainages probably experienced higher than average burning impacts. Burn intensities were high over 62% and 18% of Upper Rattlesnake and Upper Sheep Creek watersheds respectively (Figure 20). Immediately after the fire, in September of 1992, biologists examined the Upper Sheep Creek watersheds (Rieman, personal communication). They observed the following:

> "We found many dead fish and the above sections appear to be devoid of fish. The E. Fork, the main stem below the E. Fork and above Devils Creek, and the bottom of the South Fork appear to have relatively high to very high densities."

Similar observations were made in Upper Rattlesnake Creek (Corley, personal communication). It was not known to what extent the fire had reduced bull trout and redband trout numbers, because pre-fire data were unavailable, however electrofishing transects were established in both of these watersheds, and trout abundance was observed at these transects after the 1992 event. Upper Rattlesnake Creek experienced debris flooding in the winter and spring of 1997 (Figure 21), and habitats now reflect the effects of that event.

Monitoring results

As a direct result of the intense heat from the Foothills, bull trout may have been eliminated locally from some reaches of Upper Rattlesnake and Sheep Creeks. After the winter of 1997 debris floods, the next two year classes of bull trout may have been decimated, based on the numbers observed in Rattlesnake Creek, in 1999. But fish rebounded in 2000, particularly in Rattlesnake Creek where the highest densities of bull trout over the 6 year period were observed. In Sheep Creek, bull trout were observed in refuge reaches that did not experience high intensity burning or flooding (see Table 11). Redband trout numbers were up sharply in the year 2000, suggesting that post-fire habitats are becoming more productive for that species.

Table 11. Trends in bull trout and redband trout abundance in Upper Rattlesnake and Sheep Creeks after the 1992 Foothills Fire.

Upper Rattlesnake Creek (Tipton Flat) – Bull Trout

Year	Length sampled	Juvenile bt	Adult bt	Abundance (#/mi)
1994	722	15	0	33
1995	111	8	0	116
1999	536	1	0	3
2000	395	25	2	110

Upper Sheep Creek – Bull Trout

Year	Length sampled	Juvenile bt	Adult bt	Abundance (#/mi)
1992	300	35	1	188
1993	250	31	2	200
1994	300	25	1	134
1995	306	42	7	221
1999	300	10	3	54

Rattlesnake Creek - Redband Trout

Year	Length	RB	Abundance (#/mi)
1994	727.00	189.00	418.30
1995	111.00	26.00	376.88
1999	535.80	68.00	204.20
2000	392.00	316.00	1297.05

Sheep Creek - Redband Trout

Year	Length	RB	Abundance (#/mi)
1992	125	31	399
1993	250	51	328
1994	470	58	199
1995	306	112	589
1999	510	113	357

Habitat variables were measured at the 5 fish monitoring stations in Upper Rattlesnake Creek (above Tipton Flat campground – see photos in Figures 19 and 20) in 1994 and again in 2000. Debris flows occurred in this reach of stream in 1997 (see Figure 21). Table 12 displays results of these measurements. Fine sediment increases from 7 to 14 percent likely reflect increased substrate sedimentation resulting from the 1997 debris flows. Decreased width-to-maximum depth ratio probably reflects the additional channel scour resulting from higher post-fire flood regimes. Large woody debris abundance increased at these stations, reflecting the large number of dead trees that have fallen into the stream. Pool frequency declined slightly after the floods, but remains high as a result of the additional large wood debris. Much of the debris that has fallen is still suspended over the channel and, as yet, has not created pools (see figure 23).

Table 12. Habitat measurements in Upper Rattlesnake Creek 2 years after the Foothills fire, and in year 2000.

Year	Spawning Fines	Pool frequency (#/mile)	Large woody debris (#/Mile)	Width-to-Max depth ratio
1994	7%	133	202	12
2000	14%	117	350	8

Conclusions

The Foothills Fire of 1992 burned intensely within Rattlesnake and Sheep Creeks, streams which support bull trout spawning and early rearing. High intensity burning resulted in localized fish mortalities and depauparate reaches interspersed with segments containing higher densities. In Sheep Creek, high densities were found in the East Fork, immediately downstream of a severely burned reach on the main stem. Fish may have sought refuge into the lightly burned East Fork as a result of the intense heat and/or habitat alteration during and immediately after the fire. After the fire, debris flows occurred in 1997 on Rattlesnake Creek, causing increased substrate fine sediment and reduced pool frequency, presumably from filling by debris. However by the year 2000, large woody debris abundance had increased dramatically and the width-to-depth ratio of pools was greatly improved, as compared with 1994 pre-flood observations. These positive changes seemed to offset the negative effects of the debris flows, based on fish responses measured in the year 2000. Fish densities were up considerably, with bull trout abundance re-bounding to pre-disturbance levels, and redband abundances higher than any previous years' observations. The first two years after the debris flows, bull trout numbers apparently declined precipitously since only 1 fish was found in the 1999 surveys. The 1997 and 1998 year classes appeared to be missing. These effects, however were short lived as evidenced by the year 2000 observations when numerous 1+ and 0 age-class fish were found.

These findings suggest that although fish populations can be depressed, and perhaps locally decimated by fires and post-fire debris floods, the fires and floods did not produce a complete elimination of the population, and more importantly loss of the migratory component. Adults emigrating from winter rearing areas into upstream spawning areas re-establish new groups of offspring after habitats have recovered. These larger migratory fish have been observed in the natal areas in September, the spawning period. There evidence that recruitment of standing dead trees, and channel scour by increased post-fire floods, actually enhanced the local environment, in particular the structure of the habitat. Increased large woody debris and deepened pools, along with a strong vegetative response by riparian communities, and likely nutrient flushes resulting from the post-fire ash flows may account for the higher densities of both bull trout and redband trout observed in Rattlesnake Creek in 2000.

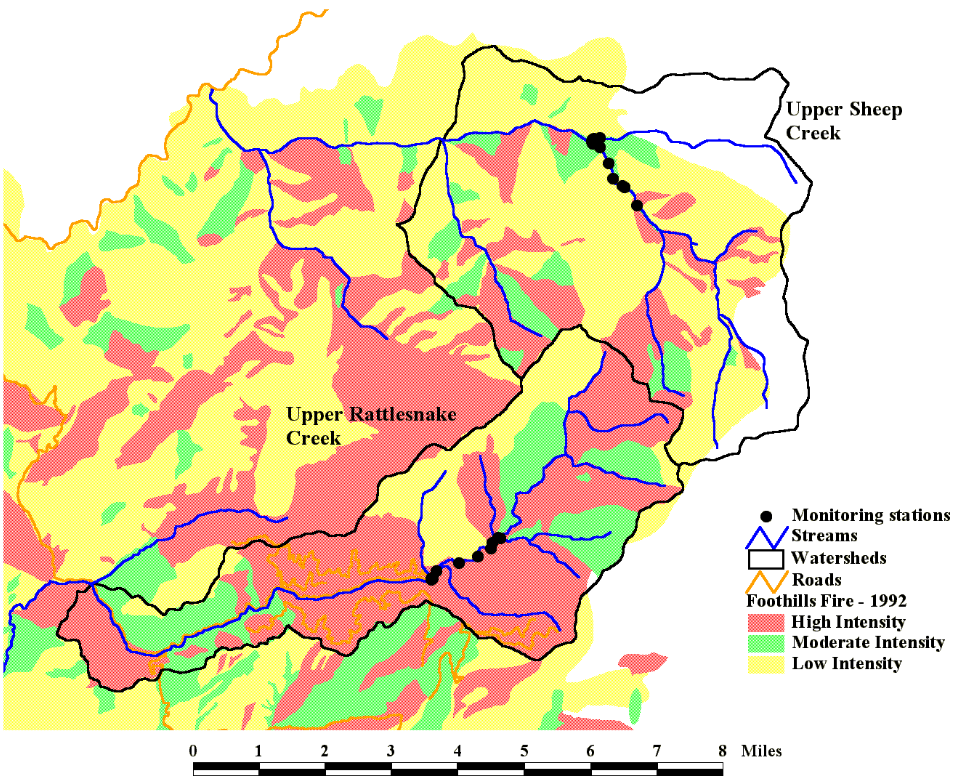

Figure 19. Upper Sheep Creek and Upper Rattlesnake Creek watersheds, showing burn intensities resulting from the 1992 Foothills Fire, and the locations of monitoring stations.

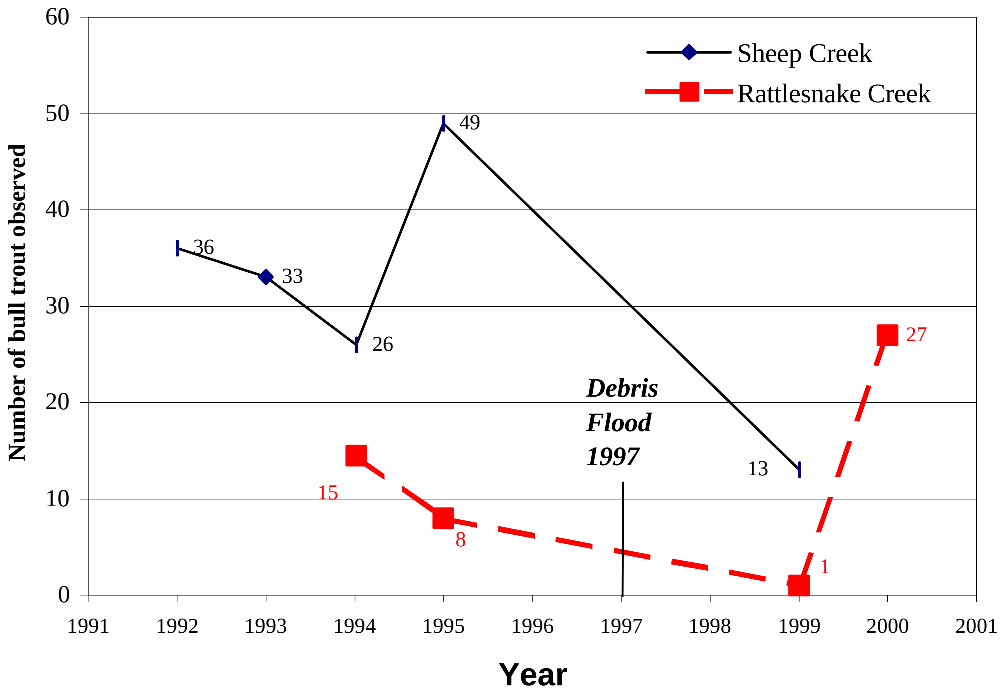

Figure 20. Trend in bull trout numbers: Rattlesnake Creek upstream of Tipton Flat.

Figure 21. Upper Rattlesnake Creek: LEFT – discontinuous patches of burned ponderosa pine and Douglas fir forests.   RIGHT – burned forests and campground tables at Tipton Flat in Upper Rattlesnake Creek.

Figure 22. Burned landscapes adjacent to Rattlesnake Creek: LEFT – Electroshocking Rattlesnake Creek near Tipton Flat. RIGHT – Dry ravel flows into Rattlesnake Creek.

Figure 23. Upper Rattlesnake Creek as seen in year 2000. Note large amounts of wood debris suspended over the channel, vigorous riparian vegetation growth, and clean substrates.

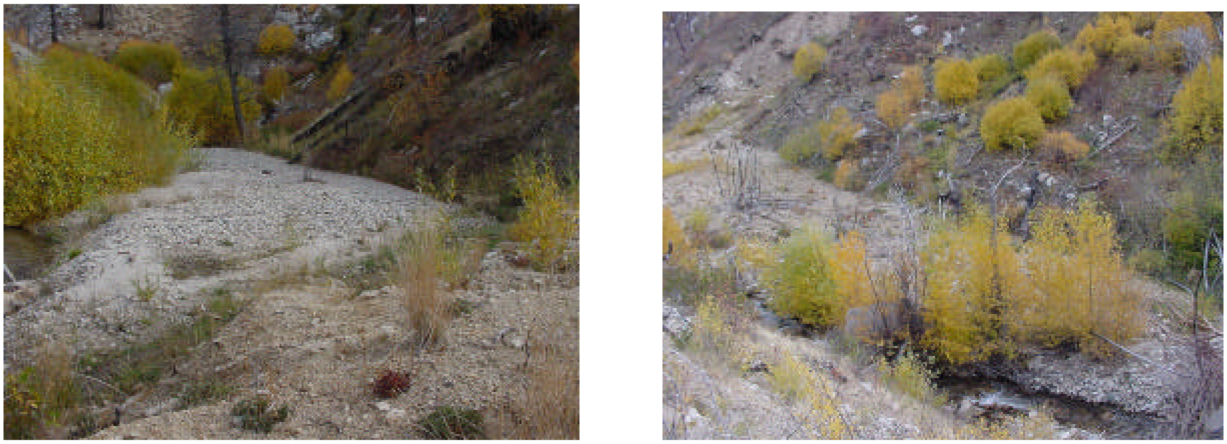

Figure 24. 1997 debris flows on Rattlesnake Creek, as seen in 2000.

THUNDERBOLT FIRE OF 1994

Introduction

In 1994, the Thunderbolt Fire burned about 19,000 acres within the upper South Fork Salmon River and Johnson Creeks on the Boise and Payette National Forests (Jacobson 1999). The Thunderbolt Timber Sale helicopter harvested timber from about 5,210 acres and implemented several sediment reduction projects designed to reduce the delivery of fine sediment (< 6mm) to the SFSR and Johnson Creek.

Thunderbolt project monitoring streams include Sister Creek, Goat Creek, Fourmile Creek, and Roaring Creek, all tributaries to the SF Salmon River, and Ditch Creek a tributary to Johnson Creek (See Figure 25). These streams have relatively steep gradients (>4 percent) with limited lower gradient reaches (<4 percent) and average from 3-10 meters in width.

Elements of fish habitat and stream channel characteristics (fine sediment, LWD, width/depth ratio, and bank stability) were measured in three randomly selected, 30-meter reaches in each of Sister Creek, Goat Creek, Roaring Creek, and Ditch Creek using USDA Forest Service Region 1/Region 4 Basin Wide Inventory Techniques (Overton et al, 1995). These sites were established and data collected in late fall of 1994 following the thunderbolt fire for use in the project EIS. These sites were sampled again prior to harvest in 1995. Sample sites in treated (harvested) areas were established in Ditch Creek and Goat Creek. A control site (burned, but unharvested) was established in Fourmile Creek.

Monitoring Results

With the exception of Sister Creek, preliminary results indicate no adverse trends in either levels of fine sediment, width/depth ratios, LWD densities, or stream bank stability in the project sample streams since the implementation of the Thunderbolt Savage Timber Sale. Intensively sampled paired-sites in Ditch Creek and Goat Creek indicate no significant differences in conditions since salvage harvest began in 1996. The few differences that occurred between the control site in Fourmile Creek and treatment sites in Ditch and Goat Creeks either existed at the start of the sampling (e.g., 1996 higher surface fines in Goat Creek) or were improved conditions compared to Fourmile Creek (e.g., 1997 lower surface fines in Ditch Creek) and cannot be attributed to salvage harvest activities.

Sister Creek experienced a localized debris torrent in 1996 that originated in the stream channel headwaters that caused localized loss of LWD and reduced streambank stability. This watershed was mostly burned at high intensity (see Figure 1).   It is unlikely that salvage logging had any substantial influence in triggering the debris torrent in Sister Creek.

Surface Fines

With the exception of one site in Roaring Creek (#2), all sample sites show average surface fine levels generally declining from 1994 through 1998. The Roaring Creek number two site showed a slight increase from 16 to 23 percent in fine sediment levels from 1996-1998. Most average surface fine levels in 1998 are less than 20 percent, with many around 10-15%.

The general improving or static trends in fine sediment levels detected at the sample sites are likely a function of wetter climatic years in 1996-1997

Width-to-depth ratio

With the exception of Roaring Creek site number two and Sister Creek number 2, wetted width/depth ratios are generally static with little change since 1994. The Roaring Creek number two site showed an increase from 20 to 47, while Sister Creek number two increased from 16 to 41. A 1996 debris torrent that started in the headwaters of Sister Creek above the salvage area likely caused the increased width/depth ratio at the Sister Creek Site.

Large Woody Debris

In general, estimated LWD levels in all sample sites dropped from those initially measured in 1994, but have remained largely static around 20-40 pieces/100 meters from 1995-1998. Sister Creek sites showed the largest flux in LWD with large reductions in 1996 and 1998. The 1996 debris torrent moved much of the in-channel LWD into Sister Creeks relatively small flood plane, with LWD levels fluctuating widely again in 1997 and 1998.

Stream Bank Stability

In general, estimated stream bank stability in all sample sites have improved from those initially measured in 1994 and have remained largely static around 90-100% from 1995-1998 (see appendix B figures 12-23).. Bank stability dropped substantially in all Sister Creek sites in 1996 following the debris torrent. Improvements in Sister Creek stream bank stability in 1997 and 1998 are indicative of bedrock stream and bank conditions.

Photographs of monitoring stream reaches are contained in Figures 26 to 29.

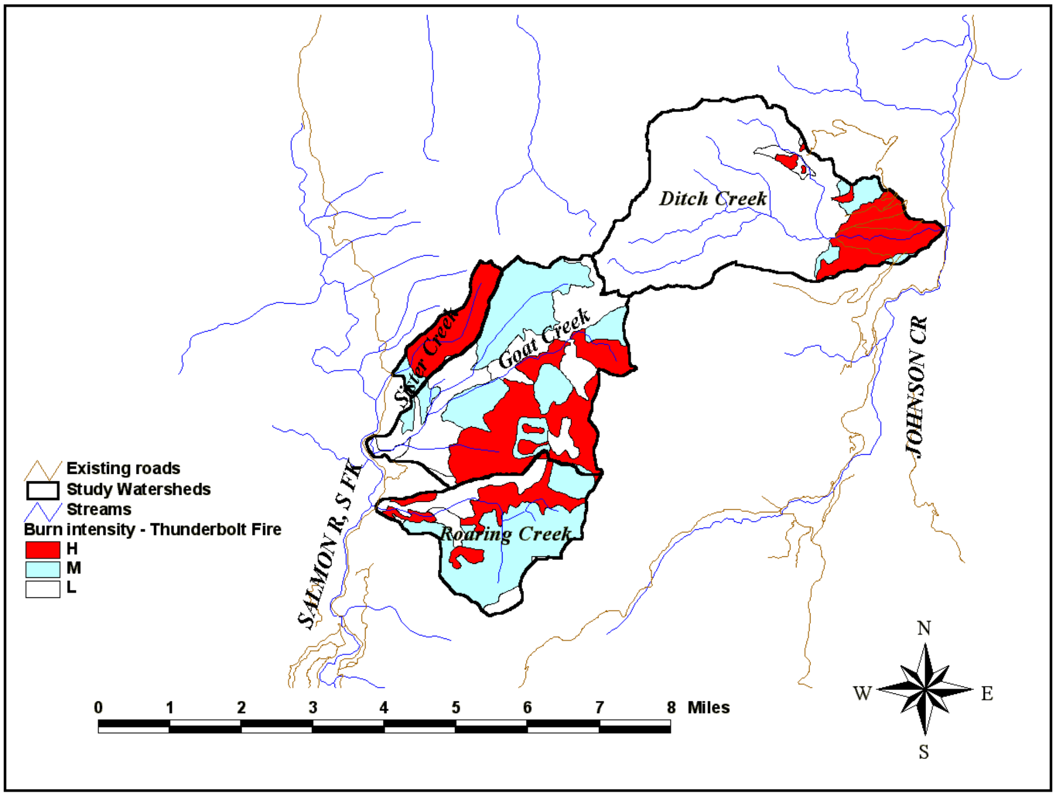

Figure 25. Burning intensities and study watersheds in the Thunderbolt Fire.

Figure 26.   1998 Ditch Creek Reach 1

Figure 27. 1998 Sister Creek Reach 1 showing post-debris torrent channel scour.

Figure 28. 1998 Goat Creek Reach 2.

Figure 29. 1998 Goat Creek Paired Site.

Conclusions

With the exception of Sister Creek, streams in the Thunderbolt Fire area have not been altered by post-fire events. The debris flow in Sister Creek resulted in declines of large woody debris and bank stability. Sister Creek was the only stream burned mostly at high intensity. Large proportions of the other watersheds burned at low intensity or did not burn. These observations suggests that where large areas burn at high intensity, post-fire debris floods are likely to occur.

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